Description of Quadrangle 13 topography excerpted from:

Valentine, P.C., Baker, J.L., and Unger, T.S., 2001, Sun-illuminated sea floor topography of Quadrangle 13 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2713, scale 1:25,000.

Introduction

The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Service. The multibeam echo sounder survey was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996. This map shows one of a series of 18 quadrangles (see location map) in which sea floor depth information is depicted in sun-illuminated (or shaded relief) view at a scale of 1:25,000, with topographic contours overprinted in blue. The image shown here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 350 degrees and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having the sun illuminate the sea floor from a position 10 degrees west of north, so that shadows are cast on the southern flanks of seabed features. Some features in the images are artifacts of data collection. They are especially noticeable where the seabed is smooth, and they include small highs and lows and unnatural-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a depiction of the topographic contours alone, and for an explanation of survey and topographic data-processing methods, see the companion map by Valentine and others (1997). Topographic contour maps of all 18 quadrangles in the map series are available on a CD-ROM in EPS, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exists.

Regional seabed features

The major topographic features depicted in the map series were formed by glacial processes. In broad terms, these features are interpreted here to represent a geologic history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment to form the large basins, banks, ridges, and valleys. Many other features observed here represent the latter stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary rotting ice, and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The sea invaded the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor is modified mainly by strong southwestward-flowing bottom currents caused by storm winds from the northeast. These currents erode sediments from the shallow banks and transport them into the basins. With time, the banks affected by these currents become coarser, as sand and mud are removed and gravel remains; and the western flanks of the banks, as well as adjacent basins, are built up by deposits of mud and sand.

Quadrangle 13 features

The northeastern quarter of this quadrangle is occupied by the southern end of a large bank (Jeffreys Ledge) that extends northeastward through Quadrangle 17 (Valentine and others, 2001a). The bank lies at a water depth of 40 to 50 m, and its surface is mainly gravel that

includes boulder piles and ridges. North of 42° 40' N., a long, rounded ridge that is less than 5 m high and that is outlined by the 40-meter depth contour trends east-northeastward across the bank for 5.5 km to the eastern edge of the quadrangle. South of this ridge, several other smaller ridges also trend east-northeastward along the bank (42° 39.7' N., 70° 27.2' W.). These parallel ridges possibly represent a series of recessional end moraines (rock debris deposited at the forward edge of glacial ice). The large ridge at 40 m water depth is poorly developed where smaller gravel ridges that trend southeastward are superimposed on it (42° 40.3' N., 70° 26.0' W.). These smaller ridges resemble eskers (sand and gravel deposited by running water in channels within stationary glacial ice). North of the ridge at 40 m, the sea floor is a complex of gravel ridges (eskers and moraines) associated with large shallow depressions that possibly mark the former locations of masses of melting glacial ice (42° 40.7' N., 70° 26.5' W.). Along the southeastern margin of the bank, a scarp of varying height (15 to 30 m) delineates the bank from an adjacent lower bank (Lower Jeffreys Ledge) to the south. The southeastern edge of the bank is capped by a sand deposit at 45 to 50 m depth that is, in part, slightly elevated above the gravel surface immediately to the north. At the base of the bank's southeastern margin, an apron of sand at 60 to 75 m depth has been transported onto the surface of the deeper adjacent bank (Lower Jeffreys Ledge). South of the sand apron, the slightly undulating surface of this lower bank is gravel that is partly covered with sand. A 30- to 60-meter scarp separates the southern and southwestern edges of Jeffreys Ledge from a large, east-southeast-trending basin (Thacher Basin); sand transported from the bank covers the northern flank of this basin. The western edge of Jeffreys Ledge is a well-defined sinuous scarp with 30 m of relief that descends from water depths of 45 or 50 m to depths of 75 or 80 m to meet the nearly flat surface of a basin (Salvages Basin). The scarp has been modified by a hummocky feature of low relief, centered at 42° 40.3' N., 70° 29.2' W., that is interpreted to be rock debris (now covered in part with sand) that was deposited by an ice fall that flowed from the bank surface above.

Outcrops of bedrock are the dominant feature in the northwestern part of the quadrangle. They are extensions of rocks exposed on the nearby islands and coast. The large basin (Salvages Basin) in the northern part of the quadrangle is bounded by these bedrock outcrops and by the bank to the east. The basin floor deepens eastward and ranges in depth from 25 m to 85 m. It is relatively smooth and is covered with mud, except where sandy mud is present along its margins near the bedrock outcrops and the bank. Several rounded hills on the basin floor (42° 39.0' N., 70° 31.4' W.) consist of gravel partly covered with a veneer of mud.

South of approximately 42° 37' N. and west of 70° 29' W., the quadrangle is characterized by hills and rounded banks (Thacher Bank, Gloucester Bank) that lie at depths of 45 to 75 m and that are surrounded by a relatively smooth seabed that slopes eastward to form several valleys in the eastern part of the quadrangle. The banks and hills are elongate, low (5 to 20 m of relief), and rounded in outline. They range from 400 m to 5.5 km in length. Their surfaces are gravel, including boulder piles and ridges; in places the gravel is covered with a thin veneer of sand that is most extensive on the hillsides. Many of these features resemble drumlins and drumlinoid ridges, which are composed of glacial debris and are the product of deposition during ice movement. By contrast, the surfaces of some of the hills and banks are covered with networks of sinuous sharp gravel ridges (42° 34.2' N., 70° 32.2' W.; 42° 35.33' N., 70° 33.0' W.), which are interpreted to be eskers. These ridges commonly are constructed of boulders and cobbles that are

now separated by voids from which sand and small gravel presumably were eroded during advance of the sea after the glacial ice melted.

A triangular bank (Thacher Bank) is present (42° 35.5' N., 70° 26.5' W.) in the southeastern part of the quadrangle. Its surface consists of rounded low hills of gravel separated by shallow depressions and small valleys. The gravel hills are covered in part with a thin veneer of sand that is more common on the hillsides than on the hilltops, and the depressions are covered with sand. This bank is bounded on the north by a basin (Thacher Basin) that extends east-southeastward through water depths of 85 to 140 m, and merges into Polygon Basin along the eastern side of the bank to a depth of 150 m. The basin floors are covered with sandy mud, the sand having been transported into the basin from the bounding banks. Within the basin, at the base of the north wall (42° 36.8' N., 70° 25.0' W.), a hummocky feature of low relief is interpreted to be rock debris deposited by an ice fall that flowed from the bank above. This feature lies partly in Quadrangle 14 to the east (Valentine and others, 2001b). Smaller features of similar origin lie along the base of Thacher Bank (42° 36.2' N., 70° 24.9' W.; 42° 35.5' N., 70° 24.9' W.). Two parallel valleys (42° 34' N., 70° 29' W.; 42° 35' N., 70° 28' W.) are present south of the triangular bank and form the head of Gloucester Basin. Their smooth floors are covered with sandy mud and extend from 85 to 90 m water depth southeastward to approximately 105 m at the southern edge of the quadrangle. In the southern part of Thacher Bank and off its western tip, narrow grooves in the seabed that typically are up to 50 m wide, less than 5 m deep, and up to a kilometer long are interpreted to be marks made by the jagged bottoms of icebergs that gouged the seabed by grounding here during the late stages of the last glaciation. They are present at 70 to 85 m water depth. Similar grooves are also present in the adjacent Quadrangle 14 to the east.

In several areas of the quadrangle, the smooth mud seabed is interrupted by shallow depressions (for example, 42° 34.9' N., 70° 30.6' W.; 42° 35.2' N., 70° 29.2' W.; and 42° 36.26' N., 70° 32.65' W.). The depressions are irregular in outline and up to several hundreds of meters in length, and some of them surround small mounds. Observations of similar features in Quadrangles 7 and 8 (Valentine and others, 1999a, b) have shown the mounds, in some places, to be patches of gravel, including boulders, that are frequented by groundfish. The depressions in the mud are interpreted to have been formed by the scouring actions of groundfish that have exposed the gravel habitat and prevented its burial by basin mud.

REFERENCES CITED

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